

Data Mining the Adoption Trends: A Bibliometric Analysis of Online Learning in Higher Education (2000-2023)

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Article history

Received: 17-06-2024

Revised: 30-08-2024

Accepted: 02-09-2024

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Abstract: Over the past two decades, online learning in higher education has developed dramatically, becoming a widespread phenomenon significantly influencing teaching and learning strategies. To further encourage its development, monitoring the research frontiers and gaining insights into the progress of related research is crucial. In this pursuit, the present research used VOS viewer to conduct a bibliometric study on the 661 documents extracted from the Scopus database published between 2000 and 2023, focusing on adopting online learning among students at higher education institutes. This study identified the development trends in this domain regarding publications, authors, countries, journals, and documents. Additionally, the study employed co-citation and co-occurrence analysis to identify the most frequently cited research papers and the trending keywords used by researchers in online learning adoption. By understanding the research frontiers and progress in online learning adoption, this study contributes valuable insights to developing and promoting online education initiatives in higher education.

Keywords: Technology Adoption, Human-Computer Interaction, Online Learning, E-learning, Higher Education

Introduction

The phrase “online learning” describes an educational approach that uses Internet technology to enable remote learning interactions (Lowenthal *et al.*, 2009). Its popularity has increased as a means of conducting academic activities without physical presence, particularly during the COVID-19 pandemic (Van Wart, 2022). Resources such as Google Classroom and Zoom Meeting have made such instruction possible. This type of learning is a powerful tool for acquiring knowledge because it has benefits, including affordability, accessibility, flexibility, and convenience (Appana and Subhashni, 2008). Furthermore, unlike traditional distance learning, online learning has developed into a unique educational format that can democratize access to education for many demographics (Dumford and Miller, 2018). The future of education will likely continue to integrate online learning methods to complement traditional educational approaches.

Online learning in higher education has significantly evolved over the past two decades, becoming a mainstream phenomenon with a substantial impact on teaching and learning methods. Integrating technology, such as online tools and learning management systems, has transformed the traditional classroom setting

(Sokout and Usagawa, 2021). Blended learning has emerged as a popular model, combining online and conventional activities to enhance academic performance and learner engagement (Yin, 2022). The shift towards online education has increased flexibility for students, especially adult learners, to access higher education programs and courses. The history of distance education from the 1800s has paved the way for the modern-day online learning environment, with the Internet playing a pivotal role in its development (Singh and Whiteman, 2020). This evolution underscores the importance of adapting to technology-enhanced learning environments to improve the standard of student learning experiences in higher education.

Online learning has drawn attention from various disciplines ranging from computer science to social science and education research over the past 20 years. Numerous academics have applied sophisticated techniques in this domain in novel ways, which has led to numerous breakthroughs in the field and several research findings. There has been vast progress in online learning. However, there are still a few unanswered questions: What are the main areas of study currently conducted in online learning? What is the current state and direction of pertinent research? What is the emerging area or trend of

current research? Although a few authors have attempted to conduct in-depth studies in this field (Xinyi *et al.*, 2023), it has not solved the problems, specifically those about students' adoption of online learning. Instead, it impedes the ongoing development of the overall research system as well as the elucidation of the summary of current research on online learning.

Additionally, it hinders researchers from following the direction of current research and from understanding essential and popular research subjects, which are necessary for accurately identifying and analyzing later research advances. Hence, a robust bibliometric analysis is urgently needed to fill this gap in the literature and significantly advance our knowledge of the dynamics underlying the adoption of online learning. Considering the above, the current investigation aims to answer the following research questions:

From the year 2000-2023, in the domain of online learning adoption:

- a. What are the development trends in the publication of scholarly research and who are the primary contributors (by year of publication, authors, countries, journals, and documents)?
- b. How are keywords interconnected within the dataset, what are the central keywords and what are the current trending topics?
- c. Which document is most influential within the field, as evidenced by its frequent co-citation with other references?

Materials and Methods

Bibliometric Tools

Bibliometrics analysis is a statistical method used to evaluate scientific publications, authors, and citations to measure research impact and identify trends (Donthu *et al.*, 2020). Researchers employ bibliometric analysis for various goals, including discovering new frontiers in the performance of journals and articles, patterns of collaboration, and research components. It can also be used to investigate the theoretical foundation of a specific field within the scope of available scholarly publications (Verma and Gustafsson, 2020). Through bibliometric analysis, scholars can effectively decode and visualize the collective scientific information and evolving intricacies of established disciplines by systematically analyzing extensive data (Donthu *et al.*, 2021). Moreover, the software offers user-friendly interfaces and customizable visualization options, making it accessible for researchers with varying levels of expertise (Van Eck and Waltman, 2010). While other tools like Biblioshiny may offer more analytical options and CiteSpace provides extensive network visualization parameters, VOS viewer's balance of functionality and ease of use makes it a preferred

choice for many researchers (Moral-Muñoz *et al.*, 2020). Hence, the present study employed a VOS viewer to conduct bibliometric analysis to map the extracted documents from the Scopus database between 2000 and 2023. VOS viewer was employed to carry out statistical analysis on authors, countries, journals, and documents and analyzed the primary research forces in online learning adoption. Additionally, the software was employed to conduct co-occurrence and co-citation analysis.

Data Retrieval

The first stage in data retrieval for a bibliometric study is choosing the database to extract the relevant data. In the present research, data was retrieved from the Scopus database. Scopus data is preferred for bibliometric studies due to its comprehensive coverage and reliability (Baas *et al.*, 2020). Scopus provides a vast collection of scholarly literature, enabling in-depth analysis of research trends, author contributions, and intellectual structures in various fields (Kumpulainen and Seppanen, 2022). However, it is essential to acknowledge the limitations of using a single database for conducting studies. It might eliminate some vital research work that is not indexed in the chosen database or some work that is published in a language other than English. It could lead to a skewed result in the global research landscape. Despite these limitations, the present study relies on the Scopus database as it allows for a detailed examination of publication trends over time, document types, and subject categories, facilitating a thorough understanding of the multidisciplinary research landscape (AIRyalat *et al.*, 2019). The extensive coverage and quality of data in Scopus make it a valuable resource for conducting comprehensive bibliometric analyses with high accuracy and relevance.

The time span selected for the present study is between 2000 and 2023. This period encompasses significant advancements in technology and internet infrastructure, greatly influencing the adoption and development of online learning platforms and methodologies. Additionally, a period from 2000 to 2023 enabled the researchers to understand the trajectory of online learning adoption, from its inception to its contemporary landscape, facilitating informed analysis and decision-making in the field. Table (1) displays an overview of the preliminary data retrieval.

Data Filtering

Filtering and screening data before conducting bibliometric analysis is essential for ensuring the accuracy, reliability, and relevance of the results. This process is completed in various stages. Firstly, removing duplicate data is crucial to avoid skewed analysis and inflating the importance of certain publications or authors. By eliminating duplicates, researchers can ensure that

each piece of data is counted only once, providing a more accurate representation of the scholarly landscape. In the present study, six research papers were found to be duplicated and removed for further analysis.

Secondly, excluding data based on missing information is essential for maintaining the integrity of the analysis. Erroneous or incomplete data might lead to biased conclusions and impede the interpretation of findings. Missing information may include incomplete citation details, author affiliations, keyword-related information, or abstracts. Although removing such papers leads to dataset size reduction, potentially limiting the analysis's comprehensiveness and affecting the study's representativeness, it was necessary to ensure that only high-quality and reliable information is included in the analysis, thereby enhancing the validity of the results. In the present study, 263 papers were found erroneous and removed from the sample.

Thirdly, applying exclusion and inclusion criteria in Table (2) in the present study helped researchers focus the analysis on specific research questions or objectives. The present study focused only on quantitative papers relevant to online learning to maintain the focus of research and ensure that the analysis is carried out of the primary data-based studies. Further, studies outside higher education were excluded since there are differences in online learning dynamics, technology adoption, and student behavior between HEIs and schools. HEIs often have more advanced infrastructure, different pedagogical approaches, and a greater emphasis on independent learning, making them a unique context that warrants separate analysis. By concentrating on HEIs, this study aims to provide more targeted and relevant insights into online learning practices and challenges specific to higher education, which may not directly apply to school settings.

Further, research papers that did not measure technology adoption behavior were excluded to concentrate on studies that directly assess the behavioral aspects of technology adoption, which are central to the research objectives. Lastly, papers lacking necessary information (e.g., abstract, author's information, keywords, and references) were excluded to ensure the inclusion of complete and verifiable studies that meet academic standards for comprehensive analysis. By applying these criteria, researchers can ensure that the analyzed dataset represents the research area of interest and aligns with the study's aims. This targeted approach enhances the precision of analysis and facilitates meaningful comparisons and interpretations of the results.

In the final stage, the data was standardized. Nguyen and Hallinger (2020) observed that the occurrence of the same term in the metadata set exported from scientific databases could cause repetition in the keyword co-occurrence network if they were not justified in

bibliometric analysis. For instance, in the dataset extracted for this study, the "Technology Acceptance Model" was mentioned as "TAM" and "Technology Acceptance Model (TAM)". Before the data analysis, a data disambiguation process was conducted and applied to the metadata set to prevent any adverse effects on the study caused by issues with the data itself (Strotmann and Zhao, 2012). Figure (1) shows the flow of retrieving and filtering the data.

Table 1: Top publishing authors on online learning adoption research

Category	Specific standard requirements
Research database	Scopus
Search period	January 2000 to December 2023
Language	English
Search term	("theor*" OR "model") AND ("technolog*" OR "ICT" OR "Information and Communication* Technolog*" OR "Information & Communication* Technolog*" OR "online learn*" OR "e-learn*" OR "e learn*" OR "electronic learn*" OR "electronic learn*" OR "web-based learn*" OR "web-based learn*") AND ("adoption" OR "acceptance") AND ("higher education institution*" OR "universit*") Social Sciences, Computer Science, Business, Management and Accounting, Arts and Humanities, Economics, Econometrics and Finance, Psychology
Subject area	Psychology
Document Type	Article

Table 2: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Research papers focusing on online learning	Research papers not relevant to online learning
Quantitative studies	Review studies or other qualitative studies
Sample should be drawn from higher educational institutes/universities.	Sample drawn from places other than higher educational institutes/universities.
Research papers studying the adoption behavior of students for learning purposes	Research papers simply evaluate technology adoption for purposes other than learning. Research papers do not measure technology adoption behavior.
Papers fully equipped with necessary information (e.g., abstract, author's information, keywords, and references)	Papers lacking in the necessary information (e.g., Abstract, author's information, keywords, and references)

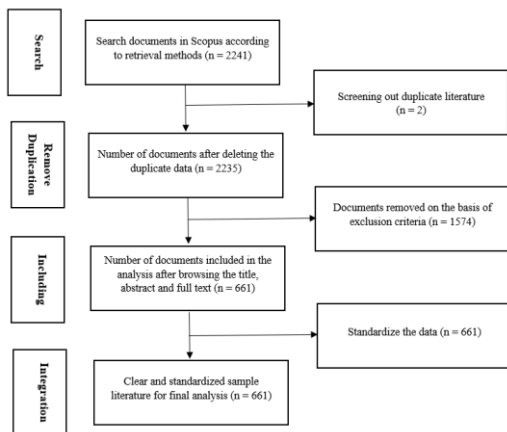


Fig. 1: Data retrieval, filtering, and standardization process (PRISMA diagram)

Results

The Development Trend of Research on Adoption of Online Learning

Understanding the publication trend over the past decades is crucial for a bibliometric study as it provides insights into the topic's evolution, popularity, and research interest. This analysis helps researchers contextualize their findings, identify emerging areas, and gauge the impact and relevance of the topic within the academic community over time. Figure (2) depicts the temporal evolution of scientific research in e-learning adoption research from 2000-2023. The data reflects a noticeable increase in publications over the past two decades, with a substantial rise, particularly from 2016 onwards, indicating growing research interest. The years 2017-2023 show significant publication growth, suggesting heightened research activity with a 158% increase in publications in this area and the emergence of new subtopics or methodologies within the field. The peak in publications in 2021 and 2022, with 100 and 106 publications, respectively, indicates a particularly intense focus on the topic during these years, majorly driven by the COVID-19 pandemic, which restricted face-to-face teaching-learning. Due to the pandemic, institutes/universities worldwide shifted to technology-assisted learning methodologies. Advances in educational technologies such as artificial intelligence and learning management systems, along with increased accessibility and global reach, can be a few more reasons behind this upsurge. While the publication surge is a positive indicator of the field's dynamism, it also raises questions about the research's quality and focus. The rapid increase in studies, especially during the pandemic, may have led to a proliferation of short-term or reactive studies to address immediate challenges rather than long-term, foundational research. Additionally, the intense focus on specific

technologies or methods could result in gaps in other areas, potentially leading to an unbalanced body of literature. Henceforth, it will be necessary for researchers to build on this momentum by conducting more rigorous, longitudinal studies that can provide deeper insights into the long-term implications of online learning adoption.

Quantitative Analysis of the Authors

Assessing the top publishing authors is crucial for a bibliometric study because it helps identify critical contributors and assess the influence of individuals within the field, providing valuable insights into the landscape of scholarly output and expertise. Table (3) presents information on the top 15 publishing authors in online learning adoption among students at higher educational institutes worldwide. Teo, T. and Al-Rahmi, W. M. are tied for the highest number of documents (17 each), with Teo having slightly more citations (1085) than Al-Rahmi (977). Teo predominantly utilized the Technology Acceptance Model (TAM) to explore technology adoption behaviors, focusing primarily on pre-service teachers to understand their intentions and attitudes toward integrating technology into future teaching practices. Al-Rahmi's work spans diverse areas, including mobile learning, social media, and MOOCs, where he applied various theoretical models such as the Technology Acceptance Model (TAM), Unified Theory of Acceptance and Use of Technology (UTAUT), and Innovation Diffusion Theory to explore factors influencing technology adoption and usage in educational contexts. Salloum, S. A. stands out with the highest average citation per paper (119.14) and a considerable number of citations (834) despite having fewer documents (7). The most cited work was by Salloum *et al.* (2019), which used a theoretical framework based on TAM and UTAUT. Overall, the analysis suggests varying levels of research productivity and impact among the listed authors, with some demonstrating exceptionally high citation impact relative to the number of documents they have produced.

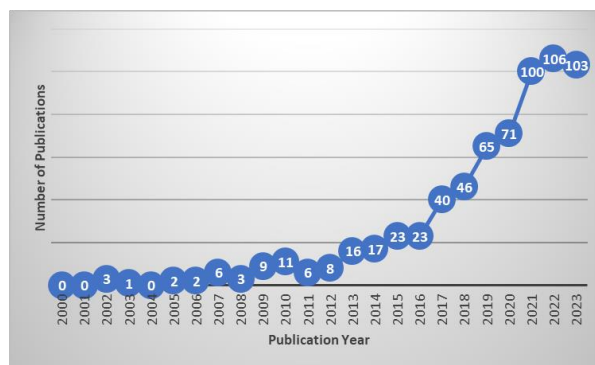


Fig 2: Temporal evolution of scientific productivity on online learning adoption research

Table 3: Top publishing authors on online learning adoption research

Rank	Author	Documents	Citations	Average citation per paper
1	Teo, T.	17	1085	63.82
2	Al-Rahmi, W. M.	17	977	57.47
3	Al-Emran, M.	9	1061	117.89
4	Alturki, U.	8	459	57.37
5	Salloum, S. A.	7	834	119.14
6	Al-Adwan, A. S.	7	347	49.57
7	Aldraiweesh, A.	7	249	35.57
8	Tarhini, A.	6	689	114.83
9	Al-rahmi, A. M.	6	221	36.83
10	Smith, S.	6	114	19
11	Alamri, M. M.	5	521	104.2
12	Almaiah, M. A.	5	381	76.2
13	Alyoussef, I. Y.	5	164	32.8
14	Buabeng-Andoh, C.	5	85	17
15	Habibi, A.	5	32	6.4

Quantitative Analysis of the Countries

For bibliometric analysis, understanding the leading publishing countries is essential since it sheds light on the geographic distribution of research efforts and helps to comprehend the worldwide landscape of advances in research in that discipline. Table (4) presents data about the top 15 countries that have contributed to the adoption of technology by students in the higher education sector since 2000. As per data, Malaysia is the top publishing country with 106 documents and 3,829 citations, averaging 36.12 per paper, followed by Saudi Arabia with 82 documents and 2,485 citations, averaging 30.3 citations per paper. Spain stands out with a relatively small number of documents (23) but a high citation count (2034), resulting in an exceptionally high average citation per paper (88.43). This information suggests that research from Spain in the field under study is highly impactful and influential despite being less prolific in the number of documents produced than other countries on the list. The low number of documents by Spain and some other countries may also be attributed to the exclusion of journals published in local languages, which were not included in the present study. Nevertheless, the present results indicate a concentration of high-quality research output in Spain within the given topic since 2000.

Quantitative Analysis of Journals

For a thorough literature review and analysis, it is helpful for bibliometric studies to know the top publishing journals on a given topic over the past years. This information is vital, considering that it can be used to identify significant sources of scholarly output, comprehend dominant trends, and identify areas where significant research contributions have been made. Table (5) highlights Education and Information Technologies as the leading journal, with 60 documents published since 2000 in this domain. The data provided in the table further highlights the distribution of documents related to online learning across various journals. Interestingly, the top journals cover a range of

interdisciplinary fields, including education, technology, psychology, and sustainability, indicating the interdisciplinary nature of the topic. This data suggests that adopting online learning among students in higher educational institutes is not only a matter of educational technology but also involves aspects of sustainability, human behavior, psychology, and emerging technologies. Hence, further studies in this field require consideration of research from diverse fields to gain a holistic understanding of this topic. Additionally, journals like the International Review of Research in Open and Distance Learning and Education Sciences are known for their open-access models, which could contribute to the broader dissemination and citation of published research. The presence of such journals in the list indicates the importance of open access in increasing the reach and impact of research on online learning adoption.

Table 4: Top countries on online learning adoption research

Rank	Countries	Documents	Citations	Average Citation per Paper
1	Malaysia	106	3829	36.12
2	Saudi Arabia	82	2485	30.3
3	China	53	1708	32.22
4	United States	49	2104	42.94
5	Jordan	41	1430	34.88
6	United Kingdom	36	1434	39.83
7	Taiwan	35	2323	66.37
8	United Arab Emirates	32	2264	70.75
9	Indonesia	32	226	7.06
10	Australia	30	697	23.23
11	Spain	23	2034	88.43
12	Iran	22	750	34.09
13	Turkey	22	488	22.18
14	Oman	20	1186	59.3
15	Pakistan	20	729	36.45

Table 5: Top Journals on Online Learning Adoption Research

Rank	Journals	Documents
1	Education and information technologies	60
2	Sustainability (Switzerland)	47
3	Computers and education	22
4	Computers in human behavior	17
5	Journal of Information Technology	14
6	Education: Research	14
7	Interactive learning environments	13
8	International journal of emerging technologies in learning	13
9	Interactive technology and smart education	13
10	Frontiers in psychology	12
11	International review of research in open and distance learning	11
12	Educational technology research and development	9
13	Behavior and information technology	9
14	International journal of information and communication technology education	9
15	International journal of data and network science	8
16	Education sciences	8

Quantitative Analysis of Articles

For bibliometric analysis, knowing which articles have received the most citations on a specific topic is crucial. This information may be used to identify critical publications, emerging trends, and significant scholars in the field. These articles act as knowledge pillars, directing further investigation and setting the course of academic discourse. Table (6) presents the top ten scholarly articles on online learning adoption research. With 657 total citations, a scholarly article by Saadé and Bahli (2005) stands out as the most cited. Its high citation count indicates its significant impact and influence on understanding cognitive factors in technology acceptance within online learning contexts. This article is closely followed by a study titled “Critical Success Factors for e-learning Acceptance: Confirmatory Factor Models” with a total of 648 citations, reinforcing its importance in identifying critical factors influencing the acceptance of e-learning platforms. The third most impactful article since 2000 is authored by Aguilera-Hermida (2020). Despite being the most recent entry on the list, it has garnered 595 citations, showcasing its relevance and timeliness in addressing the sudden shift to online learning amid the COVID-19 pandemic.

Table 6: Top 10 articles on online learning adoption research

Article's title	Author(s)	Total citations
The impact of cognitive absorption on perceived usefulness and perceived ease of use in online learning: An extension of the technology acceptance model	Saadé and Bahli (2005)	657
Critical success factors for E-learning acceptance: Confirmatory factor models	Selim (2007)	648
College students use acceptance of emergency online learning due to COVID-19	Aguilera-Hermida (2020)	595
An empirical examination of the adoption of WebCT using TAM	Ngai <i>et al.</i> (2007)	567
Determinants of user acceptance of digital libraries: An empirical examination of individual differences and system characteristics	Hong <i>et al.</i> (2002)	545
Factors determining the behavioral intention to use mobile learning: An application and extension of the UTAUT model	Chao (2019)	440
Motivational factors that influence the acceptance of Moodle using TAM	Chao (2019)	440
Can learning be virtually boosted?	Sanchez and Hueros (2010)	351
An investigation of online social networking impacts	Yu <i>et al.</i> (2010)	334
Exploring students' acceptance of e-learning through the development of a comprehensive technology acceptance model	Salloum <i>et al.</i> (2019)	328
Examining the students' behavioral intention to use e-learning in Azerbaijan? The general extended Technology acceptance model for E-learning approach	Chang <i>et al.</i> (2017)	314

This data helps understand the trajectory of research in e-learning acceptance over the past two decades. It highlights seminal works and areas of interest within the field, such as cognitive factors, critical success factors, and the impact of external events like the COVID-19 pandemic on online learning acceptance. Researchers can use this information to identify gaps, build upon existing knowledge, and formulate future research directions in e-learning acceptance.

Co-Occurrence Analysis on Keywords

Identifying top keywords in a bibliometric study enables comprehensive analysis, facilitates literature retrieval, and assists in mapping the intellectual landscape of the domain, thereby enhancing understanding and decision-making in academic research. Liu *et al.* (2023) proposed that Price's Law can determine high-frequency keywords by using the formula $M = 0.749 * \sqrt{N_{max}}$, where N_{max} denotes the highest frequency of occurrence. The current study value of M was calculated to be 11.89 (N_{max} being 252). Hence, the author's keywords with a frequency higher than 11 were taken for co-occurrence analysis.

Table (7) depicts the top keywords extracted from the selected 661 papers considered for the present bibliometric study. The technology Acceptance Model is the most frequently occurring keyword with 252 instances and the highest total link strengths of 354, indicating its significant presence and influence in literature. E-learning follows with 137 occurrences and 239 link strengths, highlighting its importance in the discourse. UTAUT and Higher Education are also notable, with 89 and 86 occurrences, respectively, suggesting substantial attention in research. The link strength between the keywords mentioned above indicates that these keywords have been frequently used together in past research.

Figure (3) taken with the help of VOS viewer software, further depicts the overlay visualization of qualifying 28 author's keywords extracted for the present study. This figure displays the evolving trend of keywords over the past few years. UTAUT, UTAUT2, higher education, PLS-SEM, MOOCs, COVID-19, online learning, learning management system, and technology adoption model are the most recent keywords used in this area. These keywords reflect contemporary trends and theoretical frameworks shaping the study of technology adoption and online learning. By incorporating these keywords, future researchers can focus on cutting-edge models and methodologies, such as the Unified Theory of Acceptance and Use of Technology (UTAUT) and Partial Least Squares Structural Equation Modeling (PLS-SEM), which provide robust tools for analyzing user behavior and technology impacts. Additionally, terms like MOOCs and learning management systems highlight current

educational technologies, while COVID-19 underscores the importance of understanding the pandemic's effect on online learning environments. These keywords will help scholars align their research with the latest developments, address emerging challenges, and contribute to a more nuanced understanding of technology adoption and online learning dynamics.

Table 7: Top author's keywords in online learning adoption research

Keywords	Occurrences	Total link strengths
Technology	252	354
acceptance model		
E-learning	137	239
UTAUT	89	157
Higher education	86	147
Mobile learning	74	134
Structural equation modeling	70	128
COVID-19	62	121
Technology acceptance	53	91
Online learning	48	88
Learning management system	47	91
Behavioral intention	34	69
Perceived usefulness	29	48
Technology adoption	28	59
UTAUT2	25	41
Students	22	44
Adoption	22	34
Self-efficacy	20	33
Universities	19	38
Perceived ease of use	18	38
University students	17	26
Acceptance	16	26
Education	15	22
PLS-SEM	14	28
Blended learning	14	23
Developing countries	12	38
Facilitating conditions	12	31
Satisfaction	12	22
MOOCs	12	16

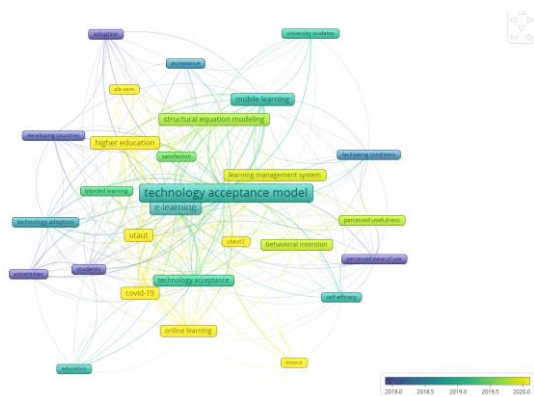


Fig. 3: Network of author's keywords trending in online learning adoption research

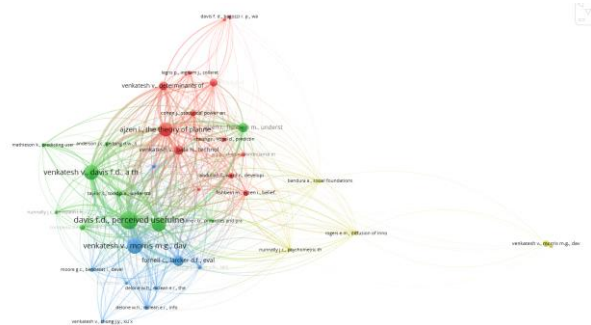


Fig. 4: Co-Citation network visualization of references in online learning adoption research

Co-Citation Mapping Analysis

A link connecting two pieces of literature cited in the same document is known as a co-citation link. Co-citation analysis is depicted in Fig. (4), with references serving as the analytical unit. Every node denotes a publication and a link between two publications indicates they were cited together. In addition, the citation weight is represented by the circle's size. Figure (4) displays the network visualization highlighting Davis (1989) to be the most cited (112 citations and total link strength of 425) and forming a green cluster with co-cited documents like (Venkatesh and Davis, 2000) (91 citations and total link strength of 372) and (Davis *et al.*, 1989) (90 citations and total link strength of 341). In the blue cluster, the other most cited document is Venkatesh *et al.* (2003) (97 citations and total link strength of 363) with co-cited references like (Fornell and Larcker, 1981) (67 citations and total link strength of 271) and (Delone and McLean 1992) (28 citations and total link strength of 122). In the red cluster, (Ajzen, 1991) (86 citations and total link strength of 323) garnered the most significant number of citations and was co-cited with other prominent references, Venkatesh and Bala (2008) (57 citations and total link strength of 211) and Venkatesh (2000) (53 citations and total link strength of 219).

Conclusion

The present study uses bibliometrics to understand the international online learning adoption research trends based on the core scholarly studies in this domain extracted from the Scopus database since 2020. Based on analyses carried out in this study, the following observations have been made:

- i. Studies conducted on online learning adoption have soared to the most incredible heights in the past five years, especially since the COVID-19 pandemic. Malaysia has emerged as the top publishing country, with a total contribution of 16% of the total papers under consideration, followed by Saudi Arabia, which made a 12%

contribution. Additionally, Teo, T. and Al-Rahmi, W.M. are the top contributing authors in online learning adoption with 17 documents each. In terms of top journals, Education and Information Technologies (under the Social Sciences area) has been the top contributing journal with 60 documents, followed by Sustainability (Switzerland) and Computers and Education (multidisciplinary area social sciences and computer science) with 47 and 22 documents, respectively. Out of all the research papers published in this domain since 2000, the scholarly article authored by Saadé and Bahli (2005) has garnered the most significant number of citations (657), closely followed by Selim (2007) with 648 citations (RQ1)

- ii. Co-occurrence analysis on keywords was conducted using VOSviewer to identify the central keywords and the current trending topics, “Technology Acceptance Model” was identified as the most frequently used keyword with 252 instances and the highest total link strengths of 354, indicating its significant presence and influence in the literature, followed by “E-learning” with 137 occurrences and 239 total link strengths, highlighting its importance in the discourse. Additionally, UTAUT, UTAUT2, higher education, PLS-SEM, MOOCs, COVID-19, online learning, learning management systems, and the technology adoption model were identified as the most recent keywords used in this area (RQ2)
- iii. To identify the most influential document in online learning adoption since 2000, co-citation mapping analysis was conducted using VOS viewer, keeping references as the analytical unit. As per the results, Davis (1989) emerged as the most frequently referred document, co-cited with Venkatesh and Davis (2000); Davis *et al.* (1989). The following most referred document was Venkatesh and Davis (2000), co-cited with (Fornell and Larcker, 1981) and (Delone and McLean 1992). The technology Acceptance Model (TAM), the foundational work by Davis (1989), has provided a solid background for modern-day research and has been instrumental in understanding how users accept and use technology. Similarly, (Fornell and Larcker, 1981) introduced vital concepts such as convergent validity, discriminant validity, and composite reliability, which have become standard criteria for evaluating the measurement models in SEM. These seminal studies have laid the groundwork for contemporary research, influencing numerous studies on adopting e-learning technologies. The ongoing relevance of their frameworks is evident in the continued use and adaptation of these models in exploring the complexities of online learning environments today (RQ3)

Implications of the Study

The present study provides insights into the evolution of scholarly research in online learning adoption over the specified timeframe. For policymakers, understanding current research trends and primary contributors helps craft evidence-based policies that address online education’s specific needs and challenges. This information can lead to more effective regulation, funding, and support mechanisms tailored to the evolving landscape of online learning. For educators, insights into trending topics and instructional strategies enable the design of curricula and teaching methods aligned with the latest research and technological advancements. It ensures that educational practices remain relevant, innovative, and practical, ultimately improving student outcomes and the overall quality of online education.

Further, examining the interconnectedness of keywords and identifying central topics enhances the theoretical understanding of key concepts, themes, and trends in online learning adoption. It reveals the underlying structures, theoretical frameworks, or emerging areas of interest within the field, contributing to theories of educational technology, digital learning, and online pedagogy. This deeper theoretical understanding allows educators to integrate cutting-edge methodologies and tools into their teaching strategies, develop more targeted and effective online courses, and address emerging challenges in digital learning. Ultimately, this knowledge helps educators enhance their instructional approaches, improve student engagement, and adapt to the rapidly evolving landscape of online education.

Additionally, identifying the most influential documents within the field will guide researchers, educators, and policymakers toward seminal works, key references, and foundational literature in online learning adoption. Educators can draw on established research to adopt proven methods and avoid pitfalls identified in seminal studies. For policymakers, influential documents supply critical insights into effective policies and interventions that have been validated through extensive research. By understanding the impact of these foundational works, policymakers can craft more effective regulations and support frameworks that enhance online learning environments. Overall, this guidance ensures that educators and policymakers base their decisions on robust, evidence-based research, leading to more effective and informed practices in online education.

Limitations and Future Research

Research on online learning adoption is necessary because it informs educational institutions, policymakers, and educators about the effectiveness, challenges, and opportunities of integrating technology into teaching and learning. It helps identify the best practices, improve instructional design, and ensure equitable access to

education, especially considering the increasing reliance on digital platforms for education delivery. Additionally, understanding online learning adoption can drive innovation in pedagogy, enhance student engagement, and address the evolving needs of diverse learners in a rapidly changing digital landscape.

Bibliometric analysis relies on available databases. In the present study, authors have extracted data from Scopus, which may not capture all relevant publications, especially those from non-indexed sources or in languages not commonly covered. This limitation could lead to a biased representation of the research landscape. Additionally, bibliometric analysis typically does not assess the quality or rigor of included studies. While it provides quantitative insights, it may not account for variations in research methodologies, sample sizes, or study designs, which could affect the reliability and validity of the findings.

Moreover, the exclusion criteria applied in the present study restrict the results of online adoption from students' perspective, thereby ignoring the other essential stakeholders in higher education. However, these drawbacks also highlight areas that warrant further investigation. Subsequent research efforts may integrate additional scientific approaches, like systematic literature reviews, to get more comprehensive data in this domain, encompassing research methodology, sample sizes, or study designs.

The present study has highlighted a significant increase in online learning around COVID-19. Future review studies can focus on the specific impact of the pandemic on advances in online learning. COVID-19, UTAUT, and UTAUT2 have also emerged as trending keywords. Future studies can also explore the UTAUT model's essential components that contribute to the adoption of online learning among varied stakeholders. Further, future bibliometric studies may consider online learning adoption from the perspectives of organizations and people involved in implementing online learning technologies. It is also proposed that meta-analysis technology can be used further to precisely determine how valuable it is to apply online learning adoption systems.

Acknowledgment

The authors did not receive support from any organization for the submitted work.

Funding Information

The authors have not received any financial support or funding to report.

Author's Contributions

All authors equally contributed to this study.

Ethics

This manuscript is an original work. The corresponding author declares that no ethical concerns are associated with this submission.

Conflict of Interest

The authors have no competing interests to declare relevant to this article's content.

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